amount of ions by making areas of the two electronic temperature regions variable with a magnetic field gradient and a distance between a wafer and a wafer facing plane.

REMARKS

SPECIFICATION AND ABSTRACT

The specification and abstract have been amended to correct certain inadvertent typographical errors and/or otherwise to improve their form.

No new matter has been added by the amendments to the specification and abstract.

CLAIM REJECTIONS UNDER 35 U.S.C. § 112

Claims 1-8 were rejected under 35 U.S.C. §112, second paragraph as being indefinite in that in claim 1, line 6, the phrase "such as" is unclear. Claim 1 has now has been amended in a manner in which it is believed satisfies all the requirements of 35 U.S.C. §112.

CLAIM REJECTIONS UNDER 35 U.S.C. §102

Claims 1-18 and 21 were rejected under 35 U.S.C. §102(a) as being anticipated by JP 11-102894A for the reasons set forth on page 3 of the Action. As discussed hereafter, it is

submitted that claims 1-18 and 21, as amended, are patentable over the JP '894A reference.

PATENTABILITY OF CLAIMS 1-18 AND 21 AS AMENDED

The present application relates to novel findings, which have been obtained by the inventor's experiments, that there is an upper limit in the distance between the antenna and wafer as shown in FIG. 4 in the SAC manufacturing method used to manufacture the device shown in FIG. 8 with an apparatus such as that shown in Fig. 1.

That is, in accordance with the present application, a high selective ratio (oxide film/nitride film, or 2nd film/1st film) can be obtained by performing SAC etching in the range wherein the generating amount of CF_2 and the generating amount of F are not reversed from each other.

In Applicants method, a distance between an antenna arranged in an etching chamber as shown in Fig. 1 and which injects electromagnetic waves and a wafer is set at a value in the range from 30 mm to 100 mm.

The claims have been amended to clarify the object of the invention and the structure produced by Applicants method, as shown in Fig. 8. The method of Applicants' invention is a contact manufacturing method called a self-aligning contact (SAC) method.

The JP 11-02894A reference is representative of the prior art which is the incentive to achieve the present invention. The JP '894A reference discloses a range of distance (20 mm-150 mm) between the antenna and the wafer in SAC manufacturing.

The JP '894A reference, however, does not disclose nor recognize the finding that the generating amount of CF_2 and the generating amount of F are reversed from each other, which has been discovered by the inventors of the present invention.

Accordingly, a person having ordinary skill in the art would not be taught nor find it obvious to select a range of 30 mm-100 mm for the distance between the antenna and the wafer from the teachings.

The Lymberopoulos et al. U.S. Patent 6,085,688 discloses that, in order to decrease damages of the work piece, an electron temperature in the vicinity of a surface is controlled by controlling a magnetic field at the surface (See col. 2, lines 35-46).

However, in accordance with SAC manufacturing, this citation does not recognize any idea that the generating amount of CF_2 and the generating amount of F relate to the distance between the antenna and the wafer in a SAC manufacturing method, as shown in FIG. 4 of the present application.

Accordingly, even if the inductively coupled plasma reactor disclosed in Lymberopoulos et al is applied to general SAC manufacturing, it is quite impossible to elicit the characteristics shown in FIG. 4 of the present application. Lymberopoulos et al therefore does not render Applicants' invention as now claimed, obvious even when combined with the admitted prior art.

Claims 1-18 and 21, as amended are therefore patentable over the prior art, taken either alone or in combination.

In view of the foregoing amendments and remarks, Applicants contend that this application is in condition for allowance. Accordingly, reconsideration and reexamination are respectfully requested.

Respectfully submitted,

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MARKED UP VERSION OF REPLACED PARAGRAPHS OF THE SPECIFICATION

Page 1, the first full paragraph, lines 5-9, the marked up paragraph is as follows:

The present invention relates to a dry etching method [using] used for fine manufacturing of semiconductor devices, particularly, to a dry etching method for realizing high-precision dry etching manufacturing of silicone oxide film.

Page 14, the fourth full paragraph, lines 16-19, the marked up paragraph is as follows:

FIG. 8 is two cross sections indicating the shapes [of] before manufacturing and after manufacturing the oxide film holes on the wafer member to be treated using [in] the present invention,

Page 14, the fifth full paragraph, lines 20-21, the marked up paragraph is as follows:

FIG. 9 is a cross section of another dry etching apparatus using [in] the present invention,

Page 14, the sixth full paragraph, lines 22-23, the marked up paragraph is as follows:

FIG. 10 is a cross section of another dry etching apparatus using [in] the present invention,

Page 14, the seventh full paragraph, lines 24-26, the marked up paragraph is as follows:

FIG. [11] 12 is two cross sections indicating the shapes before manufacturing and after manufacturing on the member to be treated using in the present invention,

Pages 14 and 15, the paragraph bridging page 14, line 27, through page 15, line 4, the marked up bridging paragraph is as follows:

FIG. [12] 13 is an illustration indicating the dependency of the injection ratio of $CF_2/(F + O)$, and the injection ratio of CF_2/ions of the member to be treated on the C_4F_8 gas flow rate using for explanation of the present invention, and

Page 15, the first full paragraph, lines 5-9, the marked up paragraph is as follows:

FIG. [13] 14 is an illustration indicating the dependency of the selection ratio at a shoulder portion of the silicone nitride film and the manufacturing shape (taper angle) on the C_4F_8 gas flow rate using for explanation of the present invention.

Pages 26 and 27, the paragraph bridging page 26, line 17, through page 27, line 12, the marked up bridging paragraph is as follows:

As the member to be treated 6, eight inches silicone wafer having the structure indicted in FIG. 8 formed on its surface is transferred from an adjacent transfer chamber (not shown in the figure) via a gate valve 16. The wafer 88 before etching is composed of a silicone wafer 87 having a gate oxide film 86 of 4 nm thick formed thereon, and [a] gate [electrode] electrodes 85 of 300 nm thick and 80 nm wide composed of polycrystalline Si and W formed on a part of the surface of the gate oxide film. Silicone nitride film 84 of 200 nm thick is formed on the upper surface of the gate electrode, and silicone nitride film 84 of 60 nm thick is formed on the side surface of the gate electrode and the upper surface of the gate oxide film so as to cover the gate electrode 85. An oxide film 83 (SOG and CVD oxide film) of 1600 nm thick (at the most thick portion) is formed on the upper surface of the silicone nitride film. Above the film, a reflection preventing film 82 of 80 nm thick and a resist mask 81, whereon a hole pattern of 130 nm in diameter is exposed and developed, of 500 nm thick are formed. The width of the oxide

film 83 existing between the gate electrode is approximately 60 nm.

Pages 30 and 31, the paragraph bridging page 30, line 12, through page 31, line 5, the marked up bridging paragraph is as follows:

Next, the oxide film etching was performed on a self-align contact (SAC) structure indicated in FIG. 8. FIG. 8 [(a)] <u>on the left side</u> indicates a cross section of the wafer before etching, and FIG. 8 [(b)] <u>on the right side</u> indicates a cross section of the wafer after etching. The result is indicated as the shape 89 after etching. After starting the etching, the silicone nitride film begins to be appeared after approximately 145 seconds. Subsequently, the etching process is finished after approximately 200 seconds. Generally, the shoulder portion 84a (at a corner portion of either right or left upper portion of the gate electrode) of the silicone nitride film 84 is readily reduced, and increasing the selection ratio at the shoulder portion 84a of the silicone nitride film 84 and the oxide film 83 is extremely difficult. However, in accordance with the condition of the present embodiment, a relatively high value, such as approximately 20, was obtained for the selection ratio of the reduction at the shoulder portion 84a of the silicone nitride film 84.

MARKED UP VERSION OF REWRITTEN CLAIMS

1. (Amended) A dry etching method comprising the steps of,

preparing a semiconductor wafer which comprises a semiconductor body, a plurality of gate electrodes formed on a main surface of said semiconductor body, a nitride film formed to cover said gate electrodes on said main surface, an oxide film formed to cover said nitride film on said main surface, and a mask film having a hole pattern formed on said oxide film, said hole pattern exposing a surface portion of said oxide film located between said gate electrodes;

disposing said wafer in an etching treatment chamber;

generating electromagnetic waves and a magnetic field in an etching treatment chamber under vacuum,

generating plasma by electron-cyclotron resonance, and

etching said surface portion of said oxide film in said hole pattern [the member to be treated such as water (hereinafter, called "wafer")] in said etching treatment chamber,

wherein

a distance between an antenna which is arranged in said etching treatment chamber and injects the electromagnetic waves, and said wafer is set at a value in the range from

30 mm to 100 mm,

the frequency of said electromagnetic waves is set at a value in the range from 300 MHz to 600 MHz,

a magnetic field gradient is set,

two kinds of electronic temperature regions are generated between said antenna and the wafer, and

an etching treatment is performed in a condition, that a gas pressure in said etching treatment chamber is in the range from 0.1 Pa to 4 Pa.

2. (Amended) A dry etching method as claimed in claim 1, further [comprises] comprising the steps of:

introducing a gas consisting of at least carbon and fluorine into said etching treatment chamber,

generating F (fluorine radicals) and ions corresponding to CF_2 in said plasma, each amount of which is independent from each other, and

performing said etching treatment.

3. (Amended) A dry etching method as claimed in claim 2, further [comprises] comprising the steps of:

introducing a gas consisting of at least carbon and fluorine into said etching treatment chamber,

determining power of a high frequency power source for generating said high electromagnetic waves, and

performing said etching treatment.

4. (Amended). A dry etching method as claimed in claim 1, further [comprises] comprising the steps of:

generating electromagnetic waves and a magnetic field in said etching treatment chamber,

generating plasma by electron-cyclotron resonance (ECR), and

performing said etching treatment.

5. (Amended) A dry etching method as claimed in claim 1, further [comprises] comprising the steps of:

introducing a gas consisting of at least carbon and fluorine into said etching treatment chamber,

generating electromagnetic waves and a magnetic field in said etching treatment chamber,

generating plasma by electron-cyclotron resonance (ECR),

determining a position of ECR,

generating F (fluorine radicals) and ions corresponding to CF_2 in said plasma, each amount of said F and said ions [is] being independent from each other, and

performing said etching treatment.

6. (Amended) A dry etching method as claimed in claim 1, further [comprises] comprising the steps of:

introducing a gas consisting of at least carbon and fluorine into said etching treatment chamber with a pre-determined flow rate, and

performing said etching treatment.

7. (Amended) A dry etching method as claimed in claim 1, further [comprises] comprising the steps of:

generating F (fluorine radicals) and ions corresponding to CF_2 in said plasma, each amount of said F and said ions [is] being independent from each other, in correspondence to an etching process of insulating film, and

performing said etching treatment.

8. (Amended) A dry etching method comprising the steps of:

preparing a wafer which comprises a substrate, a plurality of gate electrodes formed on a main surface of said substrate, a first film containing nitrogen formed to cover said gate electrodes on said main surface, a second film containing oxygen formed to cover said first film on said main surface, and a mask film having a hole pattern formed on said

second film, said hole pattern exposing a surface portion of said second film located between said gate electrodes;

disposing said wafer in an etching treatment chamber;

introducing a gas consisting of at least carbon and fluorine into [an] said etching treatment chamber under [vacuum] a reduced pressure,

generating electromagnetic waves and a magnetic field in said etching treatment chamber,

generating plasma by electron-cyclotron resonance, and

performing an etching treatment with said wafer, wherein

a distance between an antenna, which is arranged in said etching treatment chamber and injects the electromagnetic waves, and said wafer is set at a value in the range from 30 mm to 100 mm,

a magnetic field gradient is controlled by setting the frequency of said electromagnetic waves at a value in the range from 300 MHz to 600 MHz,

a generation ratio of CF_2/F is controlled by varying two kinds of electronic temperature regions between said antenna and [the] said wafer, and

an etching treatment for selectively etching said second film is performed.

9. (Amended) A dry method as claimed in claim 8, wherein

said etching treatment is performed in a manner that an electronic temperature around [the] said wafer is decreased in accordance with elapsing of the etching time corresponding to the etching treatment for contact holes of said wafer.

10. (Amended) A dry etching method comprising the steps of:

preparing a wafer which comprises a substrate, a plurality of gate electrodes formed on a main surface of said substrate, a first film containing nitrogen formed to cover said gate electrodes on said main surface, a second film containing oxygen formed to cover said first film on said main surface, and a mask film having a hole pattern formed on said second film, said hole pattern exposing a surface portion of said second film located between said gate electrodes;

disposing said wafer in an etching treatment chamber;

introducing a gas consisting of carbon and fluorine into said etching treatment chamber under vacuum,

generating electromagnetic waves and a magnetic field in [an] said etching treatment chamber [under vacuum],

generating plasma by electron-cyclotron resonance, and

performing an etching treatment with [a] said wafer, wherein

a distance between a wafer facing plane, which is arranged in said etching treatment chamber, and said wafer is set at a value in the range from 30 mm to 100 mm,

a magnetic field gradient is determined by setting the frequency of said electromagnetic waves at a value in the range from 300 MHz to 600 MHz,

two kinds of electronic temperature regions are generated between said wafer facing plane and said wafer, and

an etching treatment is performed in a condition, that a gas pressure in said etching treatment chamber is in the range from 0.0 Pa to 4 Pa.

12. (Amended) A dry etching method as claimed in claim 11, wherein

two kinds of electronic temperature regions are generated between said wafer facing plane and said wafer,

radicals and ions contributing to said etching treatment in plasma are generated, each amount of said radicals and said ions is independent from each other, and

[performing] said etching treatment is performed.

13. (Amended) A dry method as claimed in claim 10, wherein

electromagnetic waves and magnetic field are generated in said etching treatment chamber,

plasma is generated by electron-cyclotron resonance (ECR),

[determining] a position of ECR is determined, and

[performing] said etching treatment is performed.

14. (Amended) A dry etching method as claimed in claim 13, wherein

a gas consisting of at least carbon and fluorine is introduced into said etching treatment chamber,

two kinds of electronic temperature regions are generated between said wafer facing plane and said wafer,

F (radicals) and ions corresponding to CF_2 in plasma are generated, each amount of said radicals and said ions is independent from each other, and

said etching treatment is performed.

16. (Amended) A dry etching method as claimed in claim 14, wherein

F (fluorine radicals) and ions corresponding to CF_2 in said plasma are generated, each amount of said F and said

ions is independent from each other, in correspondence to an etching process of the oxide film, and

Said etching treatment is performed.

17. (Amended) A dry etching method comprising the steps of:

preparing a semiconductor wafer which comprises a semiconductor body, a plurality of gate electrodes formed on a main surface of said semiconductor body, a nitride film formed to cover said gate electrodes on said main surface, an oxide film formed to cover said nitride film on said main surface, and a mask film having a hole pattern formed on said oxide film, said hole pattern exposing a surface portion of said oxide film located between said gate electrodes;

disposing said wafer in an etching treatment chamber;

generating electromagnetic waves and magnetic filed in [an] said etching treatment chamber,

generating plasma by electron-cyclotron resonance in said etching treatment chamber, and

performing an etching treatment with [a] said wafer, wherein

a distance between a wafer facing plane, which is arranged in said etching treatment chamber, and said wafer is set at a value in the range from 30 mm to 100 mm,

a magnetic field gradient is determined by setting the frequency of said electromagnetic waves at a value in the range from 300 MHz to 600 MHz,

the generation ratio of CF_2/F is controlled by making two kinds of electronic temperature regions, which are generated between said wafer facing plane and said wafer, variable by controlling the magnetic field gradient, and

the etching treatment for selectively etching said nitride film is performed.

18. (Amended) A dry etching method comprising the steps of:

preparing a wafer which comprises a substrate, a plurality of gate electrodes formed on a main surface of said substrate, a first film containing nitrogen formed to cover said gate electrodes on said main surface, a second film containing oxygen formed to cover said first film on said main surface, and a mask film having a hole pattern formed on said second film, said hole pattern exposing a surface portion of said second film located between said gate electrodes;

disposing said wafer in an etching treatment chamber;

introducing a gas consisting of at least carbon and fluorine into [an] said etching treatment chamber [under

vacuum] so as to maintain a gas pressure in said etching treatment chamber,

generating plasma by electron-cyclotron resonance in said etching treatment chamber, and

performing an etching treatment with a wafer, wherein

a distance between a wafer facing plane, which is arranged in said etching treatment chamber, and said wafer is set at a value in the range from 30 mm to 100 mm,

each of frequencies of a high frequency power source for generating first electromagnetic waves and a high frequency power source for generating second electromagnetic waves is set at a value in the range from 300 MHz to 600 MHz, respectively,

high frequency bias having a lower frequency either of the first electromagnetic waves and the second electromagnetic waves is applied to a process platform,

the wafer is treated thereon,

two kinds of electronic temperature regions are generated between said wafer facing plane and said wafer,

F (fluorine radicals) and ions corresponding to CF_2 are generated, each amount of said F and said ions is independent from each other, and

an etching treatment is performed in a condition, that [a] said gas pressure in said etching treatment chamber is in the range from 0.1 Pa to 4 Pa.

MARKED UP VERSION OF REPLACED SECTION OF THE SPECIFICATION

Page 71 , "ABSTRACT" section, the marked up version of this section is:

[In order to provide an] An etching method for silicone oxide film by fluorocarbon plasma in semiconductor production, which is superior in precise manufacturing and highly selective to resist and silicone nitride film, includes generating two kinds of electronic temperature regions [are generated] in plasma, and controlling a generation ratio of CF_2/F [is controlled] independently from a generation amount of ions by making areas of [these] the two electronic temperature regions variable with a magnetic field gradient and a distance between a wafer and a wafer facing plane.